NASA-CR-200053

IN-12 ... 6116 P-17

FINAL REPORT FOR NASA GRANT NAG5-716

REDUCTION AND SCIENTIFIC ANALYSIS OF DATA FROM THE CHARGE-ENERGY-MASS (CHEM) SPECTROMETER ON THE AMPTE/CCE SPACECRAFT

Period Ending July, 1995

Prepared by Marian E. Greenspan, Research Associate

Under the Direction of D. C. Hamilton, Project Director

Department of Physics, University of Maryland

College Park, MD 20742

January 3, 1996

INTRODUCTION

The Charge-Energy-Mass (CHEM) Spectrometer instrument on the AMPTE/Charge Composition Explorer (CCE) spacecraft was designed to measure the mass and charge-state abundances of magnetospheric and magnetosheath ions between 1 and 310 keV/e, an energy range that includes the bulk of the ring current and the dynamically important portion of the plasma sheet population. The CHEM spectrometer operated flawlessly from launch and provided excellent quality data until tracking of the spacecraft ceased in July 1989. A continuing program of research used the AMPTE mission data set, and in particular, that of the CHEM spectrometer was carried out until funding terminated in June, 1995. During this period, 74 papers utilizing CHEM data were published or accepted for publication, and 5 additional articles have been submitted to journals. Twenty-four invited talks and 196 contributed talks using CHEM data were given at various meetings. Four PhD dissertations were based on CHEM observations. The data set provided a wealth of information on the physics of the ring current, plasmasheet, near-earth tail, and magnetospheric boundary regions.

SUMMARY of ACCOMPLISHMENTS

THE RING CURRENT

The Quiet Terrestrial Ring Current

Quiet magnetospheric conditions are of vital interest in quantifying the steady state character of the symmetric ring current. Once the ground state configuration is understood, we can go to model the storm time perturbations that produce the asymmetric ring current. We have made great strides toward this goal, compiling a data set from the quietest weeks of the recent solar minimum. We now know that the quiet ring current is 95% protons, with an energy density e-folding range from 3-6 Re. Despite the great contribution from O^+ during storms, it is a minor constituent during quiet times with about equal importance as He^+ above 4 Re. Below 4 Re, O^+ is lost to charge exchange, which is the most important loss process in the ring current. We have modelled the transport and loss processes in the ring current (using a model developed for radiation belt transport) and found that current theories break down below 11 keV or below 4 Re. We have identified several new charge exchange processes occurring in the ring current, but these did not account for the orders of magnitude failure of the model. A more likely possibility is the discovery of a new steady state transport mechanism that supplies the ring current with ions in the above mentioned regions. Coulomb drag coupled with dc electric fields produces deep penetration of ions at certain local times. This work resulted in a PhD thesis for Robert Sheldon in August 1990. Sheldon then used the CHEM data set to develop an improved empirical model for ion losses in the ring current due to convection in the magnetopause, energy loss via Coulomb drag, and charge-exchange.

Convection and Electric Fields: R. Sheldon

The effect of convection electric fields on trapped magnetospheric species continues to reveal surprises for what was thought to be a well understood phenomenon. The ionospheric dynamo creates an electric field (Richmond et al. 1980) that significantly modifies low energy (E < 30keV) particle trajectories during quiet magnetospheric conditions. Rob Sheldon has developed algorithms for tracing ions of any pitch angle through the magnetosphere using a conservation of energy approach. When applied to the quiet time AMPTE/CCE/CHEM data set, it revealed that ion drift paths depended not only on the electric field, but also significantly on ion pitch angles. The combination of these two effects greatly enhance trapping of particles into "banana" orbits that do not encircle the earth, which in turn, produce a great deal of structure in the 1-30 keV trapped ions in the magnetosphere. Adequately describing these ions even for the steady state magnetosphere has required a complete rethinking of transport processes in the magnetosphere.

Electric field convection during quiet time periods in the magnetosphere is not restricted to L>5. From a data set compiled from the quietest days in the AMPTE mission, we have evidence that plasma sheet convection can bring ions all the way in to L=2. This conclusion was corroborated by a reanalysis of papers by Williams and Frank (1984) and Williams, Lennartson and Frank (1988) which describe an intense ion peak located near L=2-3 at dusk. We were able to show that under the current magnetospheric conditions, these particles could indeed have been convected from the plasma sheet.

Large Geomagnetic Storms: D.Hamilton

While the geomagnetic tail may be described as a dynamic system, with significant activity occurring about every 20 minutes, the inner magnetosphere remains relatively quiet, with only major storms disturbing its calm. Two of the largest storms on record occurred during the CCE mission, the February 1986 storm and the March 1989 great storm. Both of these storms were characterized by a dominant oxygen component, the penetration of the ring current to low altitudes (L<2). Although spacecraft problems prevented observation of the 1989 storm's main phase, the recovery period was well documented, giving valuable information about charge exchange rates for the decay of the ring current. Deviations from the Dessler-Parker-Sckopke law relating ring current energy density and Dst were also noted.

MHD quantities of the quiescent ring current: A.T.Y. Lui and D. Hamilton

Although profiles of ring current composition and density have been published, the derived MHD quantities, which are essential for describing the MHD equilibrium of the magnetosphere, have never before been published. We derived the parallel and perpendicular pressures due to the proton anisotropies as well as the growth rates for the two major limiting instabilities in the magnetosphere, the firehose and mirror instability. As expected, the distributions showed marginal stability in an MHD equilibrium.

The Relation of Ring Current Composition and Energy Spectra to SAR Arc Intensity: J. Kozyra and D. Hamilton

Doug Hamilton has collaborated with Janet Kozyra at the Univ. of Michigan in a study of the cause of stable auroral red (SAR) arcs. In Kozyra's model the F-layer heating, which is the direct cause of the optical emission, arises from the precipitation of thermal electrons which have been scattered by Coulomb collisions with ring current ions. Detailed modeling of specific events using energy spectra measured by CHEM, have shown a rather good agreement between Kozyra's model and SAR arc production. It has been found that in some events, ring current protons are the most important ions in this process while in others, oxygen ions are more important. One surprise to come out of this study is that SAR arc events during the main phase of magnetic storms are quite common, while previously they were thought to be largely a recovery phase phenomenon.

The most recent theories of SAR arc formation suggest that they are generated by the precipitation of energetic electrons during the recovery phase of a storm when O+ ions dissipate their energy through Coulomb drag. Several interesting SAR arcs were observed during the AMPTE CCE mission, however, when the most intense emissions occurred during the main phase of the storm. CHEM data revealed that these events correlated very well with "nose events", injections of ~30 keV protons deep into the magnetosphere. Under these circumstances, Coulomb drag from protons can surpass the contribution from O+, particularly in moderate storms when the O+ densities are not as enhanced.

Helium average densities in the ring current: G. Kremser et al.

Helium phase space densities have been collected for the entire mission, and binned according to local time, radial distance, Kp index etc. First order fits to the data have been calculated using the model of Spjeldvik [1977]. At L shells below L=6, we find approximate equilibrium between transport and loss, whereas at higher altitudes, equilibrium is not found. We hypothesize that this is due to convective transport not described by the diffusive equilibrium model of Spjeldvik.

Ring current formation and decay:

CHEM data has been used to calibrate models of ring current formation and decay. V. K. Jordanova and collaborators investigated the heating of thermal ions in the outer plasmasphere via Coulomb collisions with suprathermal and ring current ions. CHEM data provided characteristic distributions of ring current ions at solar minimum for this study. It was found that the bulk of the heating of the plasmaspheric ions is produced by collisions with suprathermal ions with energies < 650 eV, rather than the more energetic ions measured by CHEM.

CHEM data from the period of minimum Dst during the magnetic storm of February, 1986 were used as input to the Ring-Current-Atmospheric Interaction Model developed at the University of Michigan during a model run simulating the recovery phase of a great magnetic storm. The ring current evolution predicted by the model was compared with CHEM measurements of the ring current at several times during the recovery phase. This work was performed by M.-C. Fok et al.

In 1995, a paper by V. K. Jordanova et al. describing their kinetic model of the ring current was accepted for publication in *J. Geophys. Res.* In the paper, CHEM data are used to provide initial ring current distributions and to check the model's predictions for H^+ and O^+ populations as functions of time, energy, and pitch angle. M.-C. Fok et al. have submitted a new paper to J. Geophys. Res. In this paper, modelling of ring current evolution during the magnetic storm of May 2-8,1986 is tested against CHEM proton distributions measured during that storm. An interesting feature of the model is its inclusion of the effects on the protons of inductive electric fields produced during substorm dipolarizations. In general, the agreement between model and data is good, but the model fails to reproduce a population of low energy ions seen near the inner edge of the ring current close to minimum Dst.

<u>Ring current energy content and asymmetry:</u>

At the Fall, 1994 AGU meeting, M. E. Greenspan reported on the results of a preliminary study on the evolution of the ring current energy content during a single storm. During this storm, CCE cut the ring current region near local midnight and near dawn. Ring current energy densities were higher by a factor of 2 to 3 at midnight than at dawn. As many previous authors had reported, the total ring current energy estimated from the CHEM ion data was less than that predicted from the Dst index by using Dessler-Parker-Sckopke relation.

A larger set of CHEM storm passes subsequently was used to compare the ring current energy content calculated from CHEM ion measurements with that predicted by the Dessler-Parker-Sckopke relation (DPS) and to investigate the variation of the storm-time ring current energy with local time. Including the effect of induced currents in the diamagnetic earth, DPS predicts that the disturbance ring current energy in KeV equals $-1.67 \cdot 10^{29} \cdot$ Dst. A method for using the pitch angle information in the CHEM ion data to calculate the variation in energy density along a magnetic field line and thus to make a more accurate estimate of the energy content was developed. This method can be used at times when the penetrating electron background is low. Using this method for 15 storm-maximum passes yielded a constant of proportionality between the ring current energy calculated from CHEM data and the Dst index of $1.4 \cdot 10^{29}$, rather than the $1.7 \cdot 10^{29}$ predicted by DPS.

Dst gives an estimate of the ring current energy that is fairly independent of local time, while the CCE spacecraft crosses about 5 hours in local time travelling between $L = 2$ and $L = 7$. Thus, the variation of the ratio of ring current energy estimated from CHEM data to Dst gives an indication of the ring current asymmetry. This variation was investigated for 16 storm-maximum passes. In agreement with previous work that indicates a stronger ring current in the dusk sector, ring current energy divided by Dst was smaller in the 0-12 LT sector than in the 12-24 LT sector. In the 12-24 LT sector, ring current energies computed from CHEM data sometimes exceeded those predicted by DPS.

<u>EMIC Waves and Plasma Parameters: Anderson & Denton</u>

Electromagnetic ion cyclotron (EMIC) waves are thought to be generated in the ring current as a result of "pancake" pitch angle distributions. The magnetometer team has collected all such events during the entire CCE mission, and correlated their properties and locations with geomagnetic indices and any other relevant index. CHEM data has been used to characterize the proton and helium ion heating both above and below the resonant energies, showing that either off equator resonance absorption or non-resonant interactions occur in the growth region. The phase space density of helium ions associated with wave events exhibits exclusively perpendicular energization. The total contribution of helium to the plasma density has been examined to determine if helium controls the EMIC occurrence.

The results of this statistical survey of occurrence probabilities for Pc1 waves were published in *J. Geophys. Res*, but as many questions were raised as answered by the survey. The free energy for the production of these waves is expected to lie in the keV energy range which the CHEM instrument measures. Brian Anderson has been able to combine the HPCE and CHEM data ranges into composite phase space density plots that reveal complex interactions between waves and particles. For example, some of the plots show a temperature reversal with energy so that at low energy the parallel temperature is higher, whereas at high energy the perpendicular temperature dominates. The theoretical models that explain these more complicated spectra have to go beyond linear theory to non-linear models that allow the waves to interact with their source spectrum.

Ion cyclotron waves and ion anisotropies: B. Anderson and G. Ho

The origin of Pc1 waves in the outer magnetosphere has been theoretically linked to the proton anisotropies in the CHEM energy range. We have examined the anisotropies and found that there is a high correlation between the plasma beta, proton anisotropy and the EMIC wave polarization and occurrence. Many of the occurrences of Pc1 waves can be traced back to compressions of the magnetosphere that increase the proton anisotropies and trigger EMIC waves.

G. Ho continued this work on the relationship of ion cyclotron waves and ion distribution functions, collaborating with D. C. Hamilton, B. J. Anderson, and S. A. Fuselier to investigate events where wave polarization changed from linear to left-hand circular or vice versa. The plasma showed a corresponding change from $\beta > 1$ (linear polarization to $\beta < 1$ (left-hand polarization). The association between polarization and β was consistent for events where only one type of polarization was seen. A difference in the growth conditions explains the high β-linear, low β-left hand polarization correspondence. For low β, ion cyclotron waves grow convectively, and $k_{\parallel} >> k_{\perp}$ modes dominate the wave spectrum but for high B, the group velocity is much lower, and $k_{\perp} \equiv k_{\parallel}$ modes become important, resulting in linear polarization.

ULF Pulsations and Plasma Parameters: K. Takahashi

We have collaborated with the magnetometer team in identifying time periods when strong ULF pulsations were observed. Giant pulsations are occasionally observed on the ground, a highly monochromatic, persistent, large amplitude wave. Since the ring current is a large source of free energy available for driving waves, as well as interacting with them, a great deal can be learned about the generating mechanism by examining the particle response. We have found for one particular pulsation, a very narrow energy band around 15 keV of ring current protons is unusually depleted, suggesting a resonant interaction. We are continuing to analyze this response to see if the current theories of bounce resonant interactions can explain these observations.

PLASMA SHEET AND NEAR-EARTH MAGNETOTAIL

Variation of Plasma Sheet Ion Composition

We have examined ion data in the near-equatorial, post-midnight magnetosphere in the range 7 <~ L <~ 9R_e for possible effects of varying solar activity, as indicated by the daily F10.7 cm solar radio flux index, and varying geomagnetic activity, as indicated by the 3-hour Kp index. The data consists of densities and average energies for plasma sheet H^+, He^{++}, He^+, and O^+ ions, in the 1.5 - 300 keV/e energy per charge range, which were collected during four CCE tail seasons from 1985 to 1989. He^{++} ions are generally considered to be of solar wind origin, while He^+ and O^+ ions are considered to be of ionospheric origin, although some He^+ can be produced from solar wind He^{++} by charge exchange. H^+ ions are an admixture from both sources. The solar F10.7 index was low (~70 - 100) for the first three intervals, during low solar activity, and high (~177-260) for the 1988-1989 interval. The most abundant ion flux was found to be that of H^+. The O^+ to H^+ number density ratio increased during disturbed geomagnetic periods and increased generally during the high solar F10.7 interval. The He^+ to He^{++} number density ratio, at values <1.0 in 1985, attained values >1.0 in 1989. These observations are in qualitative agreement with previous measurements in lower energy ranges and extend quantitative ion composition measurements to higher energies and into the rising portion of a new solar cycle.

Our analysis of long term plasma sheet ion (H+, He++, He+, and O+) composition and high charge state (Q >= 3) Carbon and Oxygen variations observed in the quasi-trapping region QTR of Earth's magnetosphere includes almost the entire mission. This long time base was necessary to facilitate the separation of spatial and temporal effects. The QTR is a region of overlapping dynamic particle distributions and boundary motions. It is found between the inner magnetosphere (L <~ 6), a region of primarily trapped particle orbits, comprised of the ring current, trapped radiation zones, and plasmasphere on the Earthward boundary, while at the outer extreme (9 < L < 12) the QTR is bounded by the low latitude boundary layer LLBL and/or magnetopause on the dayside and by the plasma sheet on the nightside. QTR local time (spatial) variations of nine individual charge states, O+3 to O+7 and C+3 to C+6, have now been determined for the first time for these two spacecraft seasons. These spatial variations in the magnetosphere, coupled with our measurements of the solar wind charge state composition [Von Steiger et al., 1991] allow us to better determine the probable source and/or entry locations of the various charge states.

The high charge state C and O ions provide a unique tracer of the solar wind within the magnetosphere, only lower charge state Oxygen, O+ and O++, are derived from Earth's ionosphere. The local time variations of solar wind primaries, O6:7 and O4:6, are different than those for their charge exchange products, O3:5 and C3. Nightside region energy spectra of all the C and O charge states are rather similar - being ordered better by energy per nucleon than by energy per charge. Solar wind primaries exhibit a maximum density-minimum temperature feature in the pre-dawn region and a near noon density minimum. In contrast, their charge exchange products exhibit a dayside density maximum and a density minimum near local midnight. These observations, coupled with computer modeling, suggest that the solar wind primaries are introduced into the QTR via the plasma sheet on the nightside, spend a few hours in the nightside QTR while circuiting the Earth, and are lost either to sunward convection into the LLBL or to charge exchange on the dayside. We see no evidence for direct solar wind plasma entry into the magnetospheric cavity inside of the LLBL on the dayside, except for special spatial/temporal regions of mixed plasma characteristics and short transient high density intervals which may simply be limited excursions into the LLBL or sheath (see Sheath, Boundary Layer, Etc. section). On the nightside the solar wind plasma has been accelerated to high energies before observation by CHEM. The local time variation of the charge exchange products suggests that they are primarily generated interior to the point of observation

We have demonstrated a method for evaluating the relative contributions of solar wind and ionospheric sources to the magnetospheric H+ plasma population based on the similarity of the spectral shapes of solar wind ions in the magnetosphere. We show that the ionosphere and the solar wind supply significant contributions of varying importance to the >1 keV/e ion populations depending on the phase of the solar cycle. Such a quantitative method will further understanding of the entry, transport, and acceleration of solar wind ions in the magnetosphere. Ion spectral and composition measurements in the 1.5-300 keV/e range from the AMPTE/CCE CHarge-Energy-Mass (CHEM) ion spectrometer at geocentric distances 7<R<9 Re in the near Earth quasi-trapping region are used to identify solar wind and ionospheric contributions to the magnetospheric H+ population during sample minimum and maximum solar activity intervals.

Radial pressure gradients: L. Kistler

The MHD equilibrium in the tail depends on both magnetic stress and particle pressures. The CHEM instrument along with a sister instrument (SULEICA) on IRM have provided important clues into the equilibrium or lack thereof in the near earth magnetotail. These results have important implications in the current 2-D and 3-D modeling efforts of the near earth plasma sheet and magnetotail.

Pressure changes in the plasma sheet during substorm injections: L. M. Kistler, E. Möbius, W. Baumjohann, and G. Paschmann

L. M. Kistler, E. Möbius, W. Baumjohann, and G. Paschmann combined data from CHEM with magnetometer data from both the AMPTE CCE and IRM satellites and data from the SULEICA instrument on IRM to determine the particle and field contributions to pressure in the plasma sheet at radial distances of 7-19 R_E before and after substorm particle injections. They found that inside 10 R_E, total pressure increased after injection, while outside 10 R_E it decreased or remained constant. Their work showed that the simultaneous appearance of energetic particles and magnetic field changes results naturally from pressure balance and is not necessarily a result of local acceleration of particles due to the changing magnetic field.

Origin, transport, and loss of energetic He^+ and He^{++}: G. Kremser

In research reported in *Annales Geophysicae*, G. Kremser et al. explored the origin, transport, and loss of energetic He^+ and He^{++} in the Earth's magnetosphere. These researchers analyzed 46 months of CHEM data. They found that, inside $L \cong 7$, phase space densities decreased with decreasing L. Modeling indicated that ion losses due to charge exchange were balanced by diffusion from larger L values, so that steady state conditions prevailed for both species. Between $L \cong 7$, and the CCE apogee at $L \cong 9$, steady state conditions continued to prevail for He^+, but not for He^{++}. The observations indicate that He^{++} is a solar wind species convected in from the distant tail, but that He^+ in the CHEM energy range is produced through charge exchange of He^{++} and through escape and energization of ionospheric He^+, with the charge-exchange the more important source.

BOUNDARY LAYERS

Sheath, Boundary Layer, Mixed Regions: S. Christon

A systematic identification of all AMPTE/CCE magnetosphere, LLBL, and magnetosheath intervals as identified primarily by CHEM measurements was accomplished. This was necessary for our long term quasi-trapping region studies and will be useful in many subsequent investigations. Supplemental magnetic field information was also used. This classification includes all transient high density intervals, which may be sheath, LLBL, or flux transfer event FTE observations. CHEM's High time resolution (6 second) He++ counting rate and spectral information facilitates this identification. In the process of separating the CHEM observations into physically dissimilar classes, we have identified a new class of magnetospheric region which possesses mixed LLBL/sheath and sphere energy spectral characteristics. These regions are characterized by an enhancement of low energy solar wind ions to levels intermediate between LLBL and nominal sphere levels. We first identified these "mixed" regions while establishing criteria for separating sphere, LLBL, and sheath data intervals.

THE MAGNETOPAUSE AND MAGNETOSHEATH

Magnetosheath Flow in the Subsolar Magnetosheath

When the apogee of the CCE spacecraft's 8.8 R_e orbit precessed through the subsolar region, the spacecraft occasionally entered the magnetosheath during magnetospheric compressions. The speed and direction of the flow of 1 to 10 keV/e H^+ and He^{++} in the magnetosheath were determined to the 3 minute resolution of the instrument. With this data set, the average flow in the subsolar magneto-sheath during magnetospheric compressions has been determined as a function of local time, and other variables. Although the average magnetosheath flow appears to originate from a stagnation point, in individual cases it may originate from a stagnation line. The He^{++} particles flow in the same direction as the protons, and with the same velocity.

Magnetopause Current Layer Observations: T.Eastman

T. E. Eastman and collaborators have studied the microstructure of the magnetopause in cases when no magnetospheric boundary layer is observed. The near-noon, low latitude CCE magnetopause crossings are complemented by ISEE 2 magnetopause crossings at a wide array of local times. The no-boundary-layer crossings, making up about 10% of the observed magnetopause crossings, are particularly interesting because the observing spacecraft may be passing through the diffusion region for reconnection. During the observed no-boundary-layer crossings, total pressure balance was conserved to within experimental uncertainty. Near local noon, the density gradient scale length at the magnetopause frequently was very small, much less than the thickness of the magnetopause current layer. Away from noon, the density gradient scale length increased, becoming comparable to the current sheet width near the dawn-dusk meridian. These observations showed qualitative agreement with the recent simulations by Drake et al. of a reconnection region due to current-convective instability.

Sheath and Leakage: N. Paschalidis

Although much has been done to characterize the population of the magnetosphere, the origin and ultimate end of this plasma has been less well established. Some of the plasma no doubt exits the magnetopause as it convects sunward under the influence of the dawn-dusk electric field. Several studies using both CHEM and the Medium Energy Particle Analyzer (MEPA) have shown that magnetospheric species of clearly ionospheric origin (O+ for example) are occasionally found in the magnetosheath, having apparently escaped through the magnetopause. While the microphysics is not fully understood, the transport is clearly related to convection electric fields, with a substantial asymmetry observed between dawn and dusk. This work has published in GRL, 1991, as well as presented elsewhere.

Dusk side leakage and Birkeland currents: N. Paschalides

Calculations of the total ion density show that the phase space densities become depleted between dawn and dusk on the day side. Since the high energy ring current ions travel clockwise, this suggests that some of the ions fail to complete a drift orbit and are lost through the magnetopause. Since these ions are part of the Region 2 current circuit, the imbalance may be compensated by increased Birkeland currents from the ionosphere. We calculate the currents required and find that the current imbalance in the ring current is of the same order as the current carried by the Region 2 Birkeland currents.

Magnetosheath Studies: S. Fuselier

Occasionally the AMPTE/CCE spacecraft crossed the magnetopause into the magnetosheath during periods of high pressure solar wind. These crossings, occurring at the apogee of the CCE orbit, have allowed unprecedented studies of the magnetosheath and associated magnetopause. Stephen Fuselier has collaborated with Brian Anderson in describing the wave and plasma environment of the plasma depletion region adjacent to the magnetopause. Usually, the relevant plasma energy is at the bottom of the CHEM instrument range, though occasionally bursts of energetic oxygen are seen. Applying some simple models of magnetospheric leakage, Stephen Fuselier has estimated that only a very small fraction of the energetic ions are leaking from the magnetosphere. Since this is an area of continuing debate, it is vital that quantitative measurements be made that may resolve the intricacies of the leakage mechanism.

Energetic magnetospheric protons in the plasma depletion layer: S. A. Fuselier used measurements of energetic ions in the plasma depletion layer (PDL) to investigate the leakage of energetic ions from the magnetosphere to the magnetosheath. When the angle between the IMF direction and the GSE x-axis is > 45°, draping of the sheath magnetic field will lead to the formation of a PDL at the nose of the magnetosphere, and ions accelerated at the quasi-parallel bow shock will not have access to this region. Analyzing data from the PDL during such periods, Fuselier found that the leaked proton fluxes were roughly 1/10 the fluxes of energetic protons typically observed upstream of the quasi-parallel bowshock. This shows that magnetospheric protons are not major contributors to the upstream energetic ion population.

Ion Beam in the Magnetosheath: M. Greenspan

Marian Greenspan has been studying a magnetosheath period during which the magnetosphere was extremely compressed. The great magnetic storm of February 1986 occurred when 1200 km/s solar wind with a strongly southward interplanetary magnetic field reached the earth. The magnetopause moved in to about 5 Re. CHEM observed several different particle populations in the magnetosphere during this active period. There was very hot shocked solar wind plasma, a more energetic component of solar composition probably accelerated by an interplanetary shock, an energetic component of magnetospheric composition, and, for a few minutes, a low energy (~2 keV) beam of O^+ and H^+ ions. The intensity of the O^+ in the beam was greater than that measured inside the magnetosphere a short time later and very likely is the result of an acceleration process at the magnetopause, possibly involving magnetic reconnection. One of the important aspects of this study is to determine whether the more energetic O^+ and H^+ ions observed within a couple gyroradii of the magnetopause have actually escaped into the sheath or are rather traveling along the magnetopause in serpentine Speiser-type trajectories alternately inside and then outside the magnetopause. These results bear on the question of how easily magnetospheric ions are "leaked" into the magnetosheath.

SOLAR WIND AND BOW SHOCK

Solar Wind and Bow Shock acceleration: F. Ipavich and G. Gloeckler

Unusually large solar wind pressures allowed AMPTE/CCE to occasionally sample the solar wind plasma in the earth's magnetosheath. Not until the launch of Ulysses in October, 1990, was a similar measurement of the solar wind composition and charge state made. Thus the AMPTE results have provided an important baseline as well as comparison for future measurements. On a very few occasions AMPTE/CCE entered the interplanetary medium, providing a unique opportunity to study the solar wind acceleration processes near the earth's bow shock, and in particular, to test the predictions of various shock acceleration theories.

In December 1991 Fred M. Ipavich presented an invited talk "Spectrum and Composition: Heliospheric Shocks" at the workshop on Particle Acceleration in Cosmic Plasmas, held at the Bartol Research Institute. A key finding in that report was derived from CHEM data taken in the region upstream of the Earth's bow shock on 1 November 1984. A well defined field aligned beam (FAB) was detected by CHEM and was both preceded and followed by Diffuse Ion Events. The He^{++}/H^{+} ratio was dramatically different in the FAB and Diffuse Ions, while the number density of H^{+} was essentially the same. In the Diffuse Events the ratio was about .03, very close to that measured simultaneously in the solar wind. In the FAB the ratio was about .0005. We conclude that disrupted FABs are not the seed population for the Diffuse Ions; rather it appears that the diffuse ions are an intrinsic characteristic of the quasi-parallel shock.